1853MNRAS..13..226R

"The companion of ζ *Herculis* has been pretty steadily visible in my telescope during the last three years.

"Between the 24th of March and the end of April we were favoured with an uninterrupted continuance of the finest astronomical weather I almost ever remember, and it was during this period that most of the above results were obtained. The eye-piece employed was a new lens of admirable workmanship,—power 500, made by Mr. Simms, with which systems of the 3d and 4th magnitude (under illumination) presented perfect discs, with scarcely a trace of rings. Indeed, nothing could exceed the beauty and sharpness of the stellar definition with this eye-piece; and I prefer it to any lower power, when the atmosphere is at all tolerably steady.

"During the magnificent weather which has prevailed since the commencement of May, the astral definition has been so deplorable that I have only obtained three sets of positions in as many weeks, with the apparent advantage of an almost continuously bright and unclouded sky. Since the beginning of the month the air has been in an exceedingly dry state, the dew-point ranging from 12° to 22°·5 below the temperature of the air.* To the very unequal distribution of moisture over the upper and lower strata of the atmosphere the twirling, moulding, and blotted appearance of the stars is, no doubt, to be attributed.

"*Observatory, Whitehaven, May* 24, 1853."

On the probable Errors of the Eye and the Ear in Transit Observations. By the Rev. T. R. Robinson, D.D., President of the Royal Irish Academy.

With respect to the usual mode of recording transit observations, and the invention recently introduced at American observatories for accomplishing the same object by means of electricity, the author remarks, that *the two systems not merely employ different senses to co-operate with sight, but that the sight itself is used in two different ways.* In the "Electric Register" the eye catches the moment when the star crosses a wire, and the touch is to synchronise with it in giving a signal. In the common modes the ear counts the clock's beats; the eye notes the distances of the star from the wire at the beats which precede and follow its passage, and thus the mind estimates the fraction of the second from the relative position of three points; all existing in memory alone, when that estimation is made.

"The error, which may be caused by uncertainty in catching the precise part of the beat which shall be taken for the origin of the second, is the same for every star (at least, if we suppose the

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* "To day (24th), at 3 p. m., the difference between the temperature of the air and of evaporation was 16°·3; and the complement of the dew-point, 24°·5 ! !"

1853MNRAS..13..226R

clock equally audible in every position of the telescope, and the observer able to observe in all with equal convenience, for personal discomfort will interfere with the attention), that arising from uncertainty in estimating the star's place will vary inversely as the cosine of its declination.

"But there is yet another, arising from the actual displacement of the star's image, by irregular changes in the refractive density of the atmosphere: the effect will, as the preceding, be inversely as the cosine of declination, but also directly as the magnitude of these changes. This depends, in the first place, on the heterogeneity of the air as to heat and moisture; and, in the second, on the quantity of disturbed medium through which the line of sight passes. The former scarcely admits of expression in terms of our present meteorological data, and we must be content to assume for it an average value. In respect to the other, as the disturbance takes place chiefly within a small distance of the earth's surface, it will easily be seen that its amount is as the secant of zenith distance. If, then, we denote by u the probable error of the ear, by y that of the eye, and by z the atmospheric tremor at the zenith, we have, by the theory of these errors, for a star whose declination is δ,

$$\varepsilon^2 = u^2 + \frac{y^2}{\cos^2\delta} + \frac{z^2}{\cos^2\delta \, . \cos^2(l - \delta)}.$$

Hence, if we select three stars, properly differing in zenith distance, we can determine the three errors, u, y, z. By a process of this kind, executed in the year 1830, the author found, from observations of his own made at Armagh:

$$u = \pm 0^{s}{\cdot}0445; \qquad y = + 0^{s}{\cdot}0619; \qquad z = \pm 0^{s}{\cdot}0381.$$

In the author's case, therefore, the ear could estimate the twenty-third part of a second, and its precision was to that of the eye as 7 : 5.

A second examination was instituted several years afterwards, certain alterations having been made in consequence of the first one.

"As the value of y was not very much less than the whole ε that I had obtained with the former eye-piece, notwithstanding its low power, a new one was obtained from the late Mr. Dollond, of 240, and very good. Nine lines were inserted by Mr. Grubb, finer and more uniform than the previous seven; the clock, whose arc of repose had been four times that of escape, had its weight changed from 4 lb. to 1·75; and a multitude of trees and shrubs were removed from the south of the transit-room, as their evaporation was a manifest cause of unsteadiness. All these, except the alteration of the clock, tended to lessen the error; that improved the rate, but it made the beat less audible in high winds, and therefore would increase u. In this instance, stars all of the first magnitude were selected. The results were,

$$u = \pm 0^{s}{\cdot}0732; \qquad y = \pm 0^{s}{\cdot}0554; \qquad z = 0^{s}{\cdot}0049.$$

1853MNRAS..13..226R

The error of hearing is considerably increased, that of sight a little lessened; but the tremor is only a seventh part of its original amount."

"It is evident that the same equations apply to the new mode of observation, if u represent the error of touch; and it is to be hoped that a similar discussion of its probable errors may be soon instituted, for there are a number of inquiries which must be answered before its superiority will be fully appreciated. Independent of the possibility, that the means employed to close and break the voltaic circuit may disturb the clock's pendulum, and that the promptness of the register may vary with the intensity of the battery, it is certain that in the obedience of the finger to the will there must be a personal equation; and it is possible that this, unlike that of the ordinary transit observer, may be variable. For any regular succession it will probably be insensible, as I infer from some observations given by Mr. Mallet, in the Report of his valuable experiments on the propagation of earthquake waves, p. 306. Starting a chronograph at a given beat of a clock, and stopping it at another, he gives the differences from the mean; whence I compute ε, for himself $= \pm\, 0^{s}{\cdot}0449$, and for his son $\pm\, 0^{s}{\cdot}0592$. Each of these involves two errors of ear and two of finger, so that the measure of one of each is $0^{s}{\cdot}0318$ and $0^{s}\,0419$. These come so near to my u, that any error of touch is scarcely possible: the case is, however, a special one, and may be compared to the counting seconds without a clock, which a practised observer will do with surprising accuracy. Phenomena not regularly recurring could scarcely be taken so accurately.

"The error of sight will, for the reason already given, be less in the case of stars; as to the sun and moon, it is more doubtful. In the transit they have larger probable errors than the stars. For the sun I obtained, in 1830, the first limb $\pm\, 0^{s}{\cdot}116$, the second $\pm\, 0^{s}{\cdot}087$; the moon gave $\pm\, 0^{s}{\cdot}149$; while stars observed at the same hour, and near the same parallel, had but $\pm\, 0^{s}{\cdot}097$. This greater uncertainty arises from the strong contrast between the bright and dark surfaces whose boundary we take; and a similar one may be expected in attempting to note the precise instant of its passage.

"As to tremor, it will act here precisely as in transit observations; and it may, moreover, perhaps nullify one of the proposed advantages, that of making many observations in a few seconds. The undulations of the air are twofold,—those of short period, which cause the flutter that produces z, and those of much longer duration, which, without blurring the star, displace it, and sometimes cause the pole star, after crossing the wire, to go back, and after ten or even fifteen seconds make a second transit. In the present mode, such waves affect only a single wire, and may be neutralised by others; but in the other they would vitiate the whole set."